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<p>We adapted and completed the spectral unsupervised clustering algorithm in terms of modern high-dimensional nonparametric density estimation methodology. This led to the completion of the unsupervised spectral classification part of our system. We then studied possibilities to improve our method of geo-spatially biased sampling of pixels. One of these techniques, based on a Bayesian geo-spatial local/global density quotient seems to be the most promising to provide efficient spectral samples for the ensuing, second, unsupervised spectral classification step. Finally, we completed the third step, the allocation of all pixels in the image to the system of classes in the second step in terms of two optional methods.</p>					
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# Unsupervised Spatial Feature and Change Detection in RS Imaging

First Interim Report

**Principal Investigator**  
Prof.dr R.J. Mokken

*1 July 1998*

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19981006 047

### **(1) Scientific work during report period**

We adapted and completed the spectral unsupervised clustering algorithm in terms of modern high-dimensional nonparametric density estimation methodology:

- we studied, developed and implemented density based proximity measures (*i.e. cylindrical envelopes*) to be used together with  $k$ -NN ( $k^{\text{th}}$ -nearest neighbour) methods in order to assess class-inclusion/exclusion of spectral data points;
- we studied criteria for minimal density, taking into account the correction for the 'curse of (high)dimensionality'.

This led to the completion of the unsupervised spectral classification part of our system.

We then studied possibilities to improve our method of geo-spatially biased sampling of pixels, designed to produce a spectral sample for unsupervised classification, which would:

- be biased toward spectrally homogeneous, noiseless (*i.e. non-mixed*) pixels and
- warrant an adequate selection of scarcely distributed classes vs. classes which are dominant in a particular image.

This led to the implementation of four optional modes of pixel sampling from an image an image:

1. homogeneous, non-stratified;
2. homogeneous stratified;
3. biased random, stratified;
4. local/global density ratio sampling.

The latter technique, based on a Bayesian geo-spatial local/global density quotient seems to be the most promising to provide efficient spectral samples for the ensuing, second, unsupervised spectral classification step.

Finally, we completed the third step, the allocation of all pixels in the image to the system of classes in the second step in terms of two optional methods:

1. plain nearest neighbour allocation;
2. allocation by principal component projection.

We received and accepted an invitation to participate in an open workshop which was held at Kingston University, near London, in the UK, on May 18<sup>th</sup> – 21<sup>st</sup>, 1998. It was sponsored by the European Commission – Environment and Climate RTD Programme, concerning the concerted action project "MAVIRIC" [Machine Vision in Remotely Sensed Image Comprehension]. The number of workshop participants was limited to approximately 60 of which 45 (three per EU member state) were invited at the expense of the MAVIRIC Concerted Action. Under those terms one of us (drs.

Cees van Kemenade) made a technical paper presentation concerning our approach during the workshop. We then were asked to submit a short article after the workshop which is expected to be included in a new book on the MAVIRIC theme, scheduled to appear in the Lecture Notes in Computer Science series Springer Verlag. Title: Density-based unsupervised classification for remote sensing. Authors: Cees H.M. van Kemenade, Han La Poutré and Robert J. Mokken. The draft paper is attached in print and as a Postscript file (mav.ps).

We then received an invitation to contribute a chapter to a book *Spatial Statistics for Remote Sensing*, to be published by the International Institute for Aerospace Survey and Earth Sciences (ITC) at Enschede, Netherlands, and in preparation by dr. Freek van de Meer of that institute. The editorial formula of this book is based on the comparison of various methods of classification and analysis on a common Landsat data set of the regio Enschede. We were asked to contribute a description of our method of unsupervised classification and the results of its application to that data set.

These results look rather promising, as reported in our draft chapter. Title: Density-based unsupervised classification for remote sensing. Authors: Cees H.M. van Kemenade, Han La Poutré and Robert J. Mokken. A first draft of this chapter is attached in print and as a Postscript file (UNSUITEC.ps).

## **(2) Research plans for the remainder of the period.**

In the next period we will prepare the presentation of the prototype for density-estimation based unsupervised image classification for our partners at CRREL/RSGIS, Hanover (NH) October 5-7, 1998. This can then be used as a research base for discussion of the strategy to be followed in further development of the project in terms of its proposal. We propose first to concentrate on innovative optimisation of the establishes features of our prototype with an eye on spectral de-mixing and change detection.

Anticipated further work is the development of non-parametric models more general than the linear singular value decomposition within classes. We will investigate whether recent neural network theory based on radial basis functions (RBFs), and the use of spiking neurons can show the same promises here as were propagated elsewhere. Together with the use of evolutionary computation methods to search for models for demixing of clusters consisting of multiple classes, and the usage of Bayesian methods to exploit the spatial the spatial structure during pixel classification. Spatial structure is exploited by computing prior probabilities over a spatial neighbourhood, and use these to compute posterior pixel classification probabilities.

**(3) Significant administrative actions during the report period**

During the reported period there has been no change in personnel involved in the project.

**(4) Other important information**

None

**(5) Statement showing the amount of unused funds**

See attachment.

**Annex to**

**First Interim Report (01 April-30 June 1998)**

**Unsupervised Spatial Feature and Change Detection in RS and Imaging**

**contract no. N 68171 98 C 9012**

**contractor Prof.dr R.J. Mokken**

**ALL/CCSOM, PSCW, University of Amsterdam**

**1. Statement showing amount of unused funds at the end of the covered period**

1st Incrementally Funded Period	remainder	\$	29,931.00
April 98 - March 99			
2nd Incrementally Funded Period	total	\$	43,898.00
April 99 - March 00			
3rd Incrementally Funded Period	total	\$	48,867.00
April 00 - March 01			
<b>total unused funds at end of covered period</b>		<b>\$</b>	<b>122,696.00</b>

**2. List of important property acquired with contract funds during this period**

none